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LIME AN ESSENTIAL FACTOR IN FORAGE.

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The scientific feeding of live stock is to so feed, that the purpose for which the animal is reared or kept is accomplished without waste of nutrient material. When a ration is so compounded that this result is obtained, the ration is said to be balanced. In balancing rations consideration has for the most part been given to the ratio between the protein on the one hand and the carbohydrates and fat on the other. These are food ingredients proper. They furnish heat and energy, as well as replace the waste of the body. In addition to these, certain inorganic, or ash, ingredients are necessary for animal life or growth. Among these the most important are, phosphorus, sulphur, lime, iron and potash.

In the course of analysis of a number of Hawaiian grown fodders [1] it was found that many contained so little lime that it would be impossible for an animal to eat enough to obtain what is usually recognized as the requisite amount of this ash ingredient.

This lack of lime in many of our grasses and forage plants no doubt explains the failure to obtain the best results, which

[1] These analyses will be published in full as Bulletin No. 13 of the regular series of this Station.

sometimes follows the feeding of what is otherwise a properly balanced ration.

The Function of Lime in the Plant:—The role which lime plays in plant life is not very well understood. It is usually absent from young tissues, and is found for the most part in the walls of adult cells, where it is present in organic combination. It may also be present as a by-product as crystals of oxalate of lime deposited in the cells. The higher plants cannot develop normally without lime, and for this reason it is regarded as being necessary for plant life.

Function of Lime in the Animal:—Lime forms an essential part in the bones of animals and it is abundant in milk. More than 2% of the live weight of a full grown, well fed steer is lime. Cows' milk contains more lime than does lime water,[1] generally in excess of 0.15%. Lime constitutes about 20% of the ash of milk, and generally more than 1.5% of the total solids.

A lack of lime in food will result in improper bone development in the growing animal. This impaired development of the bony skeleton will of course react on the general growth of the animal, and the purpose for which the animal is fed, whether it be the production of beef or milk or of work, will not be attained. In extreme cases a diseased condition of the body may result.

Sources of Lime:—Lime enters the animal body both in food and drink. All flowering plants contain some lime, as do all natural waters. Surface waters, however, in Hawaii, except in coral formations, contain but small amounts of lime or other mineral ingredients. Whether lime in the form of purely mineral salts such as carbonate or sulphate present in water, is as good a source of lime for the animal as the organic combination present in plants, is not known. In fact the whole question of the needs of animals for mineral food stuffs has been neglected, and published analyses for the most part, give the total ash without any consideration of its composition.

Lime Varies in Foods:—The variation in the lime content

[1] Lime water is a saturated solution of lime in water. At 80° F. such a solution will contain about 0.09% lime.

of materials used for human food is shown by the following figures:

100 lbs. dry material	Contain lbs. lime.
Beef	0.029
Wheat	0.065
Potato	0.100
Egg albumen	0.130
Peas	0.137
Human milk	0.243
Yolk of egg	0.380
Cows' milk	1.510

In fodder plants and materials the variation is quite as wide. There are three factors which influence this variation which should be considered in this connection:

I. Different species of plants growing under the same conditions have the power of taking up from the soil, and incorporating in the plant tissues different amounts of inorganic substances. As an example of this, sorghum and alfalfa growing side by side were found on analysis to contain:

	Sorghum	Alfalfa
Potash	0.41	0.84
Lime	0.05	0.45
Phosphoric Acid	0.15	0.30

II. Plants of the same species grown upon different soils may contain different amounts of ash ingredients. If an ash ingredient is present in the soil in a soluble form, in large excess over the needs of the plant, the plant tissues will contain an excess of this ingredient. A marked example of this was noted in comparing sisal fiber from Sisal Plantation with that from the Experiment Station. The total ash in each was approximately the same. In the case of the fiber from Sisal Plantation where the soil is disintegrated coral, 40% of the ash was lime, while in that from the Experiment Station, where the soil contains less than 1% lime the amount was but 7%.

III. Different parts of the same plant contain different amounts of ash ingredients. In other words the mineral matter taken from the soil becomes localized in the plant. Seeds are rich in phosphorus, leaves and straw in potash, old mature cells richer in lime than growing parts.

Amount of Lime necessary:—It has been found that to maintain full grown oxen the fodder should contain 0.10 lb. of lime

per day. In the case of milch cows a yield of 20 lbs. of milk would contain 0.03 lb. lime, and from this it may be concluded that approximately the amount of lime required by milch cows is 0.13 lb. per day.

The food capacity of an average cow or steer may be taken as approximately, 100 lbs. of green fodder per day. Among the fodder samples analyzed, a large number were found to contain so small an amount of lime that in order to obtain 0.13 lb., the animals would have to eat green fodder much in excess of 100 lbs. per day.

Fodders Low in Lime:—The following examples will sufficiently illustrate this:

Sample	% Lime	Lbs. green fodder necessary to furnish 0.13 lb. Lime.
Sorghum (4)	0.05	260
Cane Tops	0.01	1300
" " (2)	0.04	325
Para Grass	0.06	216
" "	0.08	162
" "	0.09	144
Kaffir Corn	0.01	1300
" "	0.04	325
Millet	0.04	325
Cassava Root	0.07	185
" "	0.04	325
Panicum crus-galli	0.02	650
Hilo Grass	0.08	162
Buffalo Grass	0.06	216
Pilipiliuli	0.02	650
Kukaipua	0.06	216
Eleusine indica	0.04	325

A number of samples of grasses both wild and cultivated, were found to contain lime in excess of these figures. One sample of sorghum contained 0.15%. Guinea grass (2 samples) 0.22 and 0.17%. Manienie or Bermuda grass, 0.14%. Paspalum dilitatum (2 samples) 0.10 and 0.12%. Pili grass 0.26%. While too few samples have been analyzed to warrant making any general statement as to average composition, there are sufficient data to warrant the conclusion that forage plants of the grass family grown in Hawaii, are low in lime; some extremely so.

Among the concentrated fodders used to increase the amount of protein in the ration, many are low in lime. A sample of

bran was found to contain but 0.07% of lime, requiring 200 lbs. per day to give the required amount. Rice bran, (two samples) contained 0.15 and 0.08% respectively. Cocoanut meal, 0.08%. Barley contains 0.05 to 0.10%. It is easily seen from these figures that these concentrates in the amounts used to balance a ration, cannot make up any deficiency of lime in a sorghum or grass ration.

Fodder Material High in Lime:—Among green fodders the legumes are decidedly higher in lime content than the grasses. Two samples of alfalfa were found to contain 0.45 and 0.41% respectively. Spanish clover (*Meibomia uncinata*) 0.19% and *Meibomia triflorum* 0.70%. Algaroba beans (two samples) contained 0.28 and 0.34% respectively. Two samples of algaroba seeds alone, contained 1.00 and 1.10%.

Among miscellaneous fodder materials furnishing lime, may be mentioned dried brewers grains with 0.25%, linseed meal 0.40% and waste molasses. The lime content of waste molasses is quite variable and it is not possible to state the average amount present. Two samples of molascuite or sugar bran made from such molasses, contained 0.87 and 1.00%.

Consequences of Feeding a Ration Deficient in Lime:—The results which follow a lack of lime in the fodder have been already outlined but it is desired to emphasize particularly one point; the relation of lime to milk production. Experimental data are lacking on this point, but physiological considerations point to the conclusion, that the amount of lime in the fodder may very easily be the limiting factor in milk production.

The amount and composition of the ash in the fluids, blood, milk, etc., of an animal body are remarkably constant. There is, in health, a constant adjustment of the distribution of the mineral ingredients, and any wide variation from the normal ash composition of the fluids of the body is an indication of diseased or abnormal conditions. Those who have to do with live stock generally realize the importance of lime to the young growing animal in furnishing bone material, but many do not realize the comparatively large amount of lime in milk. This high lime content is of course really a provision of nature to meet the needs of the young animal.

There is abundant evidence to prove that the lime content of cows milk does not vary, except within narrow limits, even

under very diverse conditions of feed. In the case then, of a milch cow fed a ration deficient in lime, the milk secreted still contains approximately the same percentage of lime, and to meet the deficiency of lime in the food, either the production of milk must decrease or the deficiency be made up from the tissues of the body. In the latter case the general health and vigor of the cow is affected, resulting ultimately in a decrease in the milk.

How to Meet a Deficiency of Lime in Fodder:—In a general way the answer to this question is suggested by the foregoing statements of analyses. Shortly it may be said that a deficiency of lime in fodder may be met:

1. By growing a larger proportion of leguminous crops for green fodder.

2. By feeding such concentrates as algaroba beans, waste molasses or products made from it.

3. By supplying natural water containing more lime, or lime water.

4. By the application of lime or fertilizers containing lime to forage crops of the grass family. Armsby in his Manual of Cattle Feeding, recommends the use of leached wood ashes sprinkled over the food.

For range cattle the introduction of legumes on the ranges or such grasses as may be found to take more lime from the soil, are the most obvious remedies.

Cases are on record in Hawaii, where cattle have become diseased from the lack of lime in grass fodder. When such conditions indicated by emaciation, soft bones, etc. arise, a veterinarian should be consulted.

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